Radio Access Network Architecture Wideband CDMA systems

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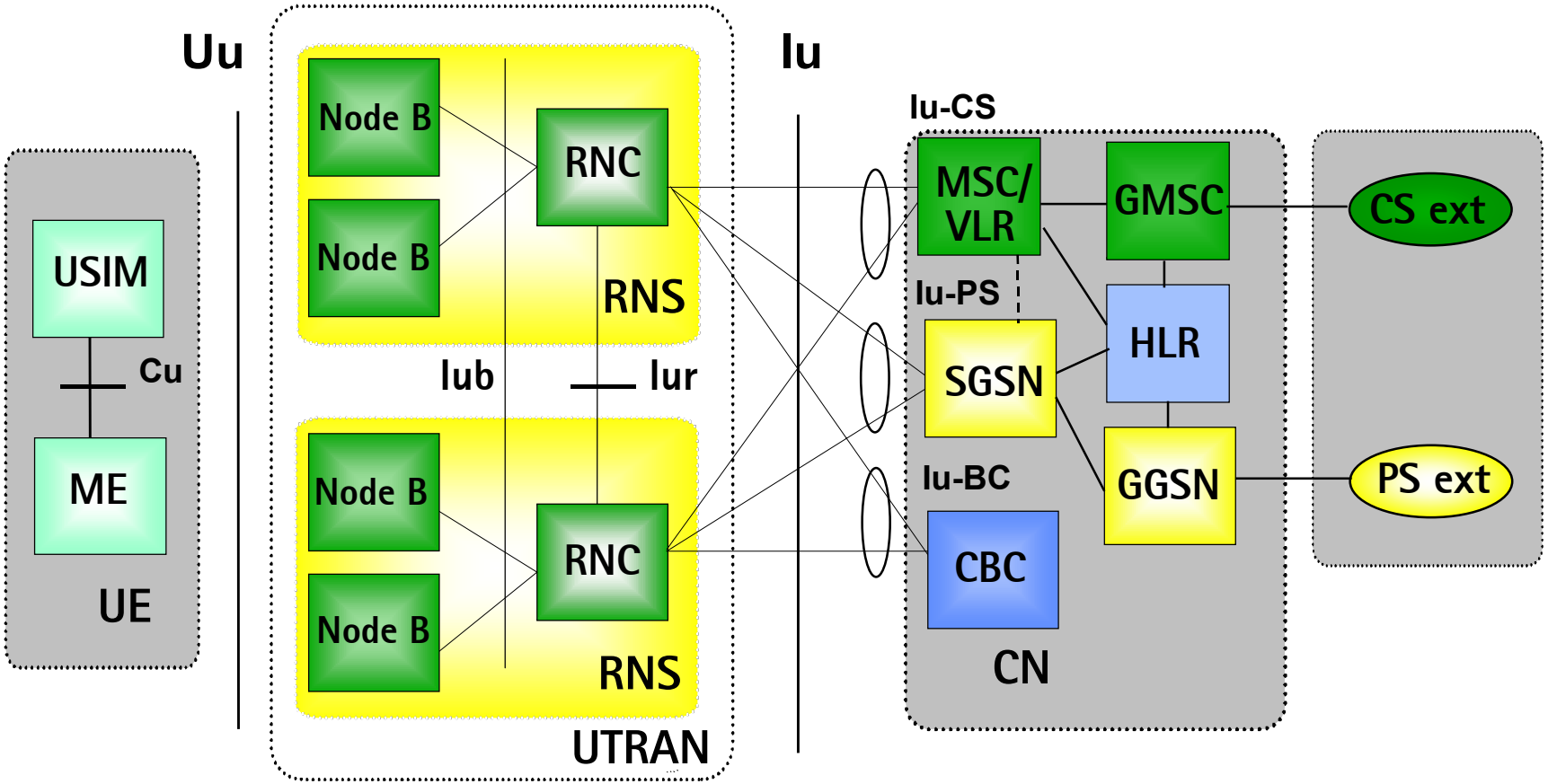
Architecture and Nodes

UTRAN and System Architecture

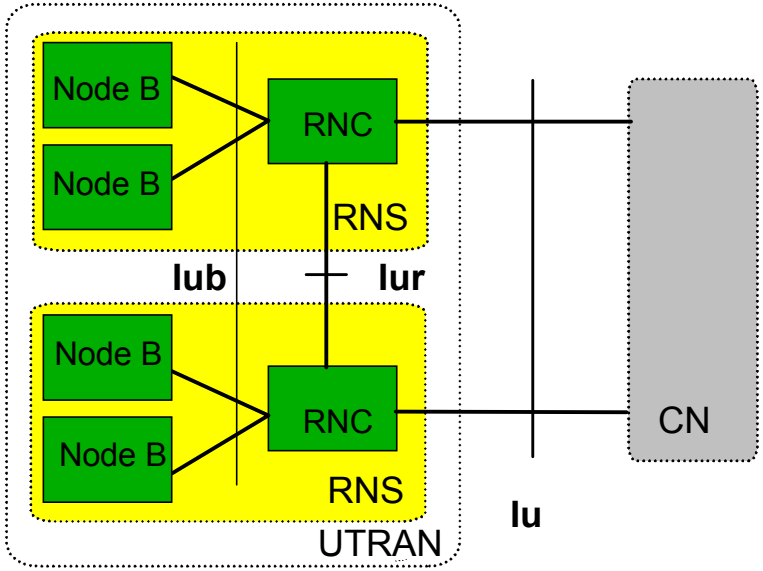


UTRAN Definitions General

- WCDMA radio is the main difference in 3rd generation UTRAN compared to GSM BSS
  - UTRAN architecture development was mainly based on familiar principles and concepts from GSM
  - No need for conceptually new network entities
- The entities in UTRAN are: Radio Network Controller (RNC) and Base Station (BS)
  - Note that standards use terminology Node B for Base Station
- At a high level their functionality is similar to GSM BSC and BTS respectively
- New reference point Iur is added between RNCs for macro diversity soft HO
- RNC has "general purpose" Iu interface to connect to CN

UTRAN Basic Concepts

- UTRAN consists of a set of Radio Network Subsystems connected to the CN through Iu.
- RNS consists of a Radio Network Controller and one or more Node Bs. A Node B is connected to the RNC through Iub interface.
- A Node B can support FDD mode, TDD mode or dual-mode operation.



- RNC is responsible for the Handover decisions that require signalling to the UE.
- RNC comprises a combining/splitting function to support macro diversity between different Node B.
- Node B supporting the FDD mode can comprise an optional combining/splitting function to support macro diversity inside a Node B.
- Inside the UTRAN, the RNCs can be interconnected together through the Iur. Iu and Iur are logical interfaces. Iur can be conveyed over physical direct connection between RNCs or via any suitable transport network.

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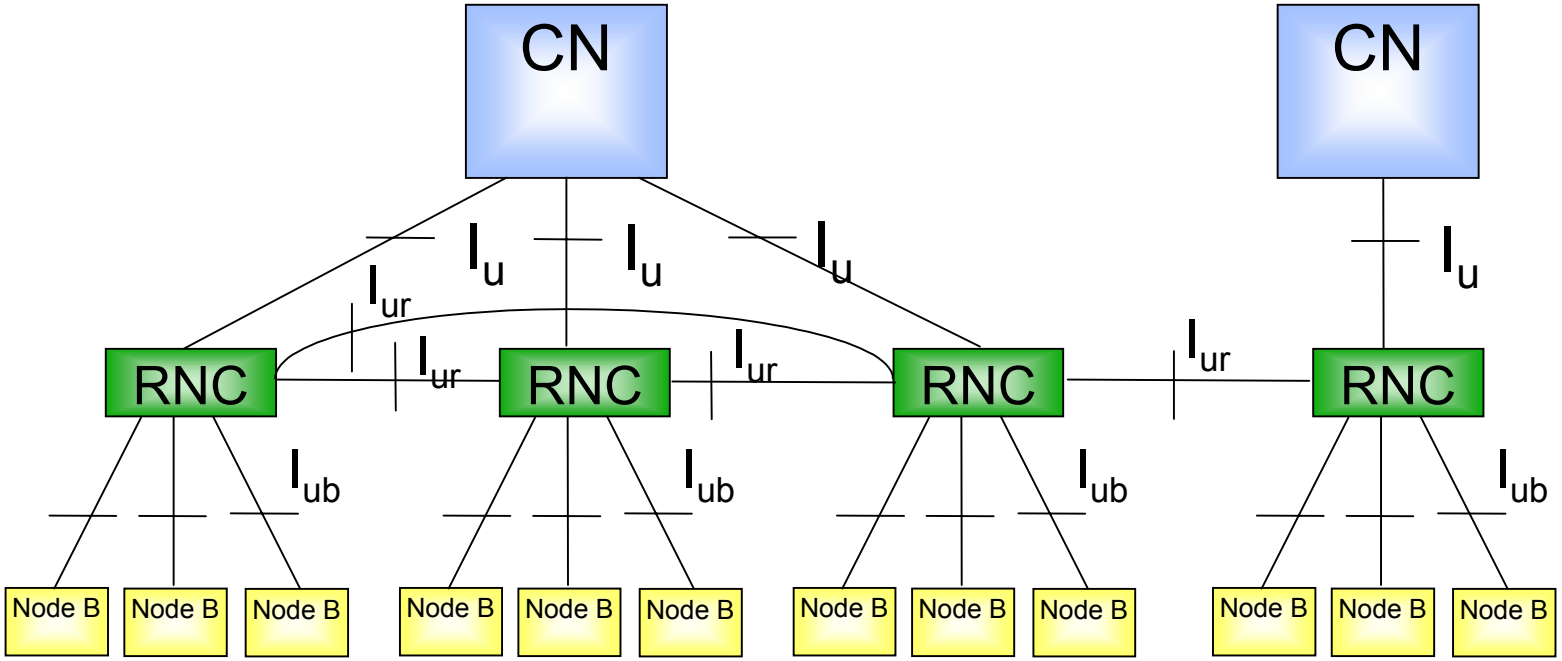
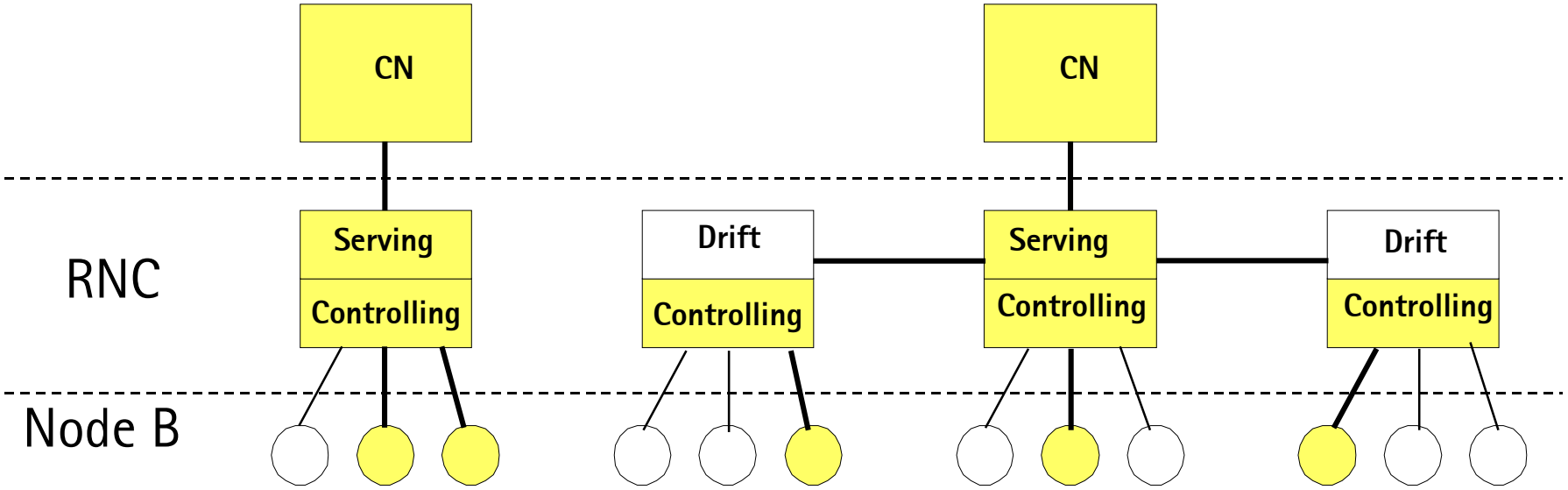
Hierarchical UTRAN Architecture



- One higher layer entity controls several lower layer entities
- Lower layer entity has only one master, it can be connected to only one higher layer entity of the type (RNC and different CN domains)

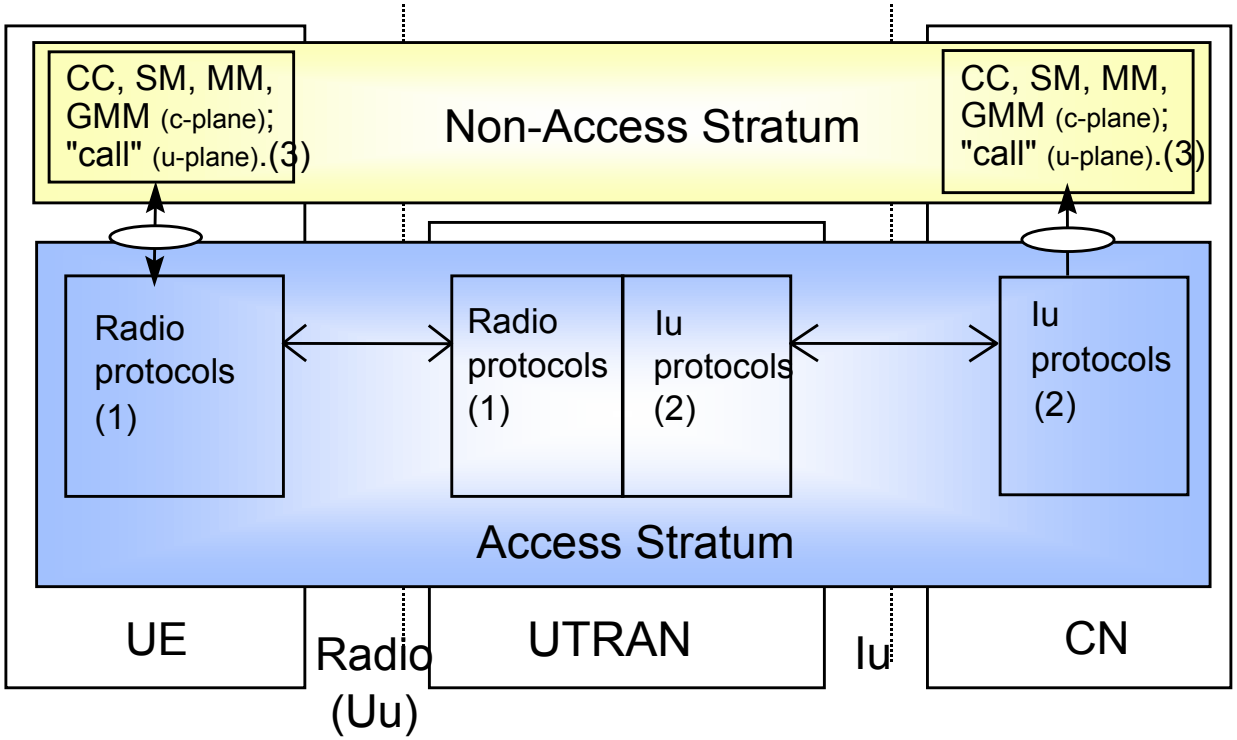
RNC Roles

- Concerning one connection between UTRAN and one UE , the following roles of RNCs exist:
  - Serving RNC that controls the connections to a UE
  - Drift RNC that lends its resources for the Serving RNC for a particular UE
- Each RNC also has the Controlling RNC role towards its Node Bs



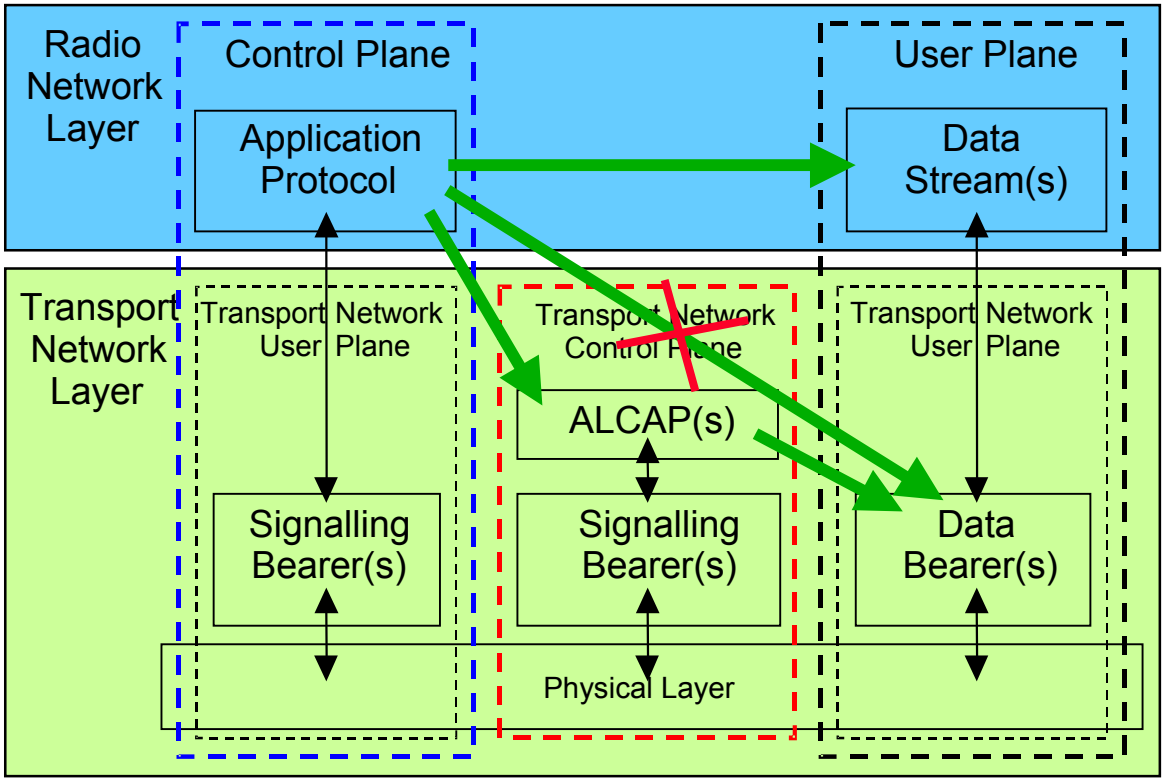
General Protocol Principles in UTRAN

Access Stratum and Non-Access Stratum



- Communication between UE and CN is in Non-Access Stratum
- Access Stratum provides services for Non Access Stratum
  - UTRAN is in the Access Stratum
  - Iu is in the Access Stratum

General Protocol Model for UTRAN Terrestrial Interfaces



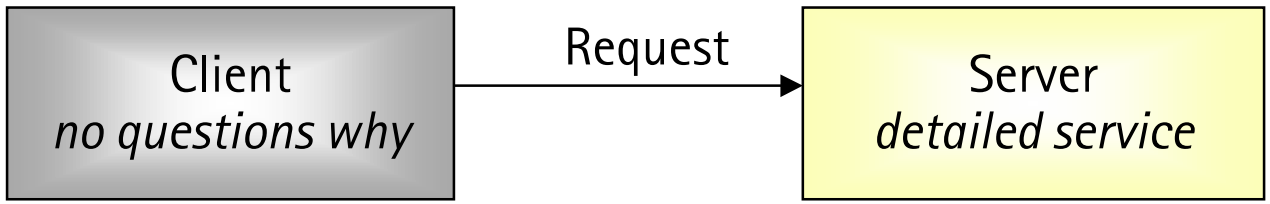
- The layers and planes are logically independent of each other
- If needed, Transport Network may be changed in the future by decisions in the standardisation.

Elementary Procedures (EP)

- Three classes:
  - Class 1: request and response (failure or success)
  - Class 2: request without response
  - Class 3: request and possibility for many responses
- Independent of each other (interactions specified in special cases)
- Successful and Unsuccessful (if applicable) operation as well as Abnormal Conditions (if applicable) specified for each EP
- Elementary Procedures are specified in the interface specifications (stage 3 specifications)
  - Using several EPs together is specified in stage 2 signalling flow specifications

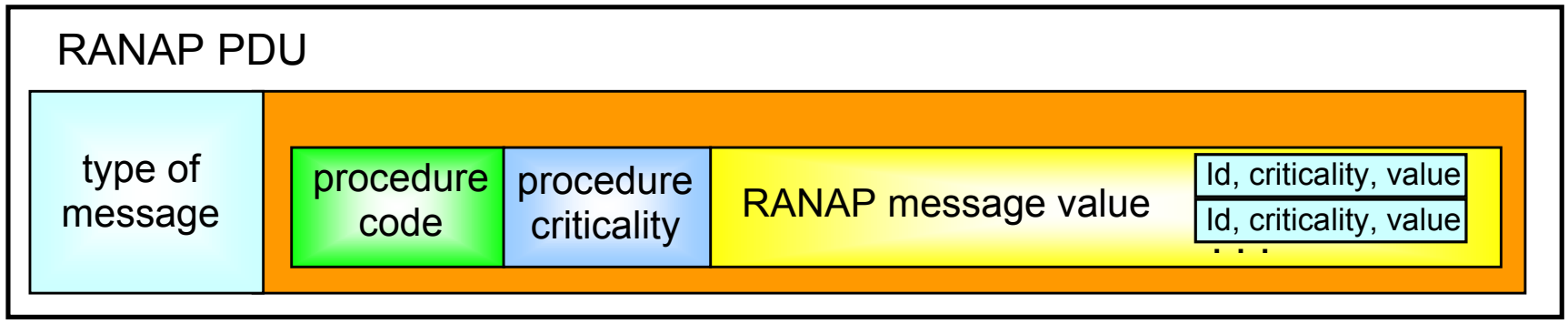
Client - Server model

- Behaviour of Client unspecified (only usage of optional IEs specified)
- Behaviour of Server specified clearly and thoroughly



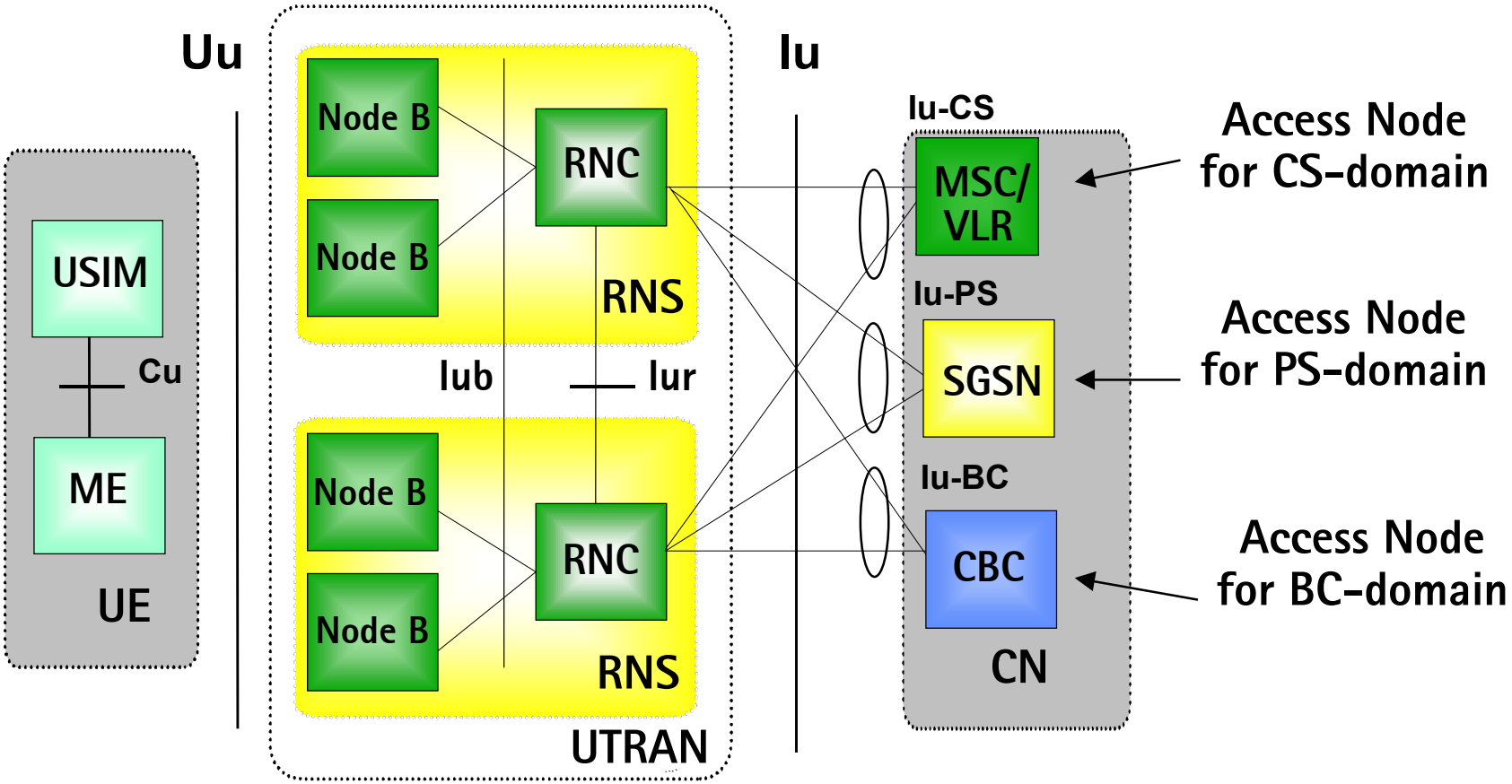
Backwards and Forwards Compatibility

- So called "Comprehension Required" principle applied
- No version number in messages
- Procedures and main IEs have "explicit ID" and "Criticality" indicating what is requested from the receiver if not understood
- The structure for ID and criticality can always be decoded, i.e. that structure is never changed
- Allows IEs from different standard versions in one message
- Requires handling of information above the ASN.1 en/decoding



Iu Interface

Iu Interface Concept



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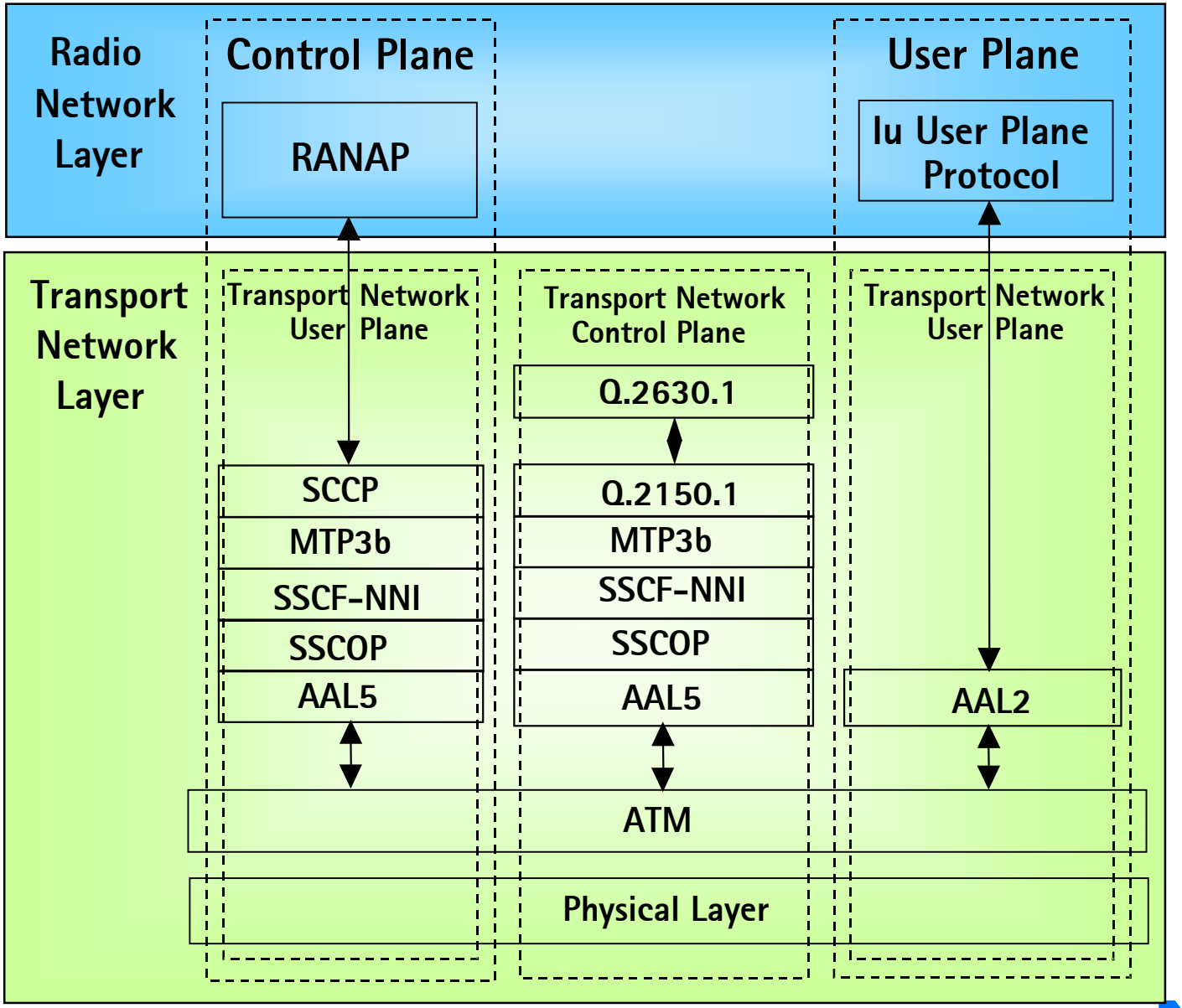
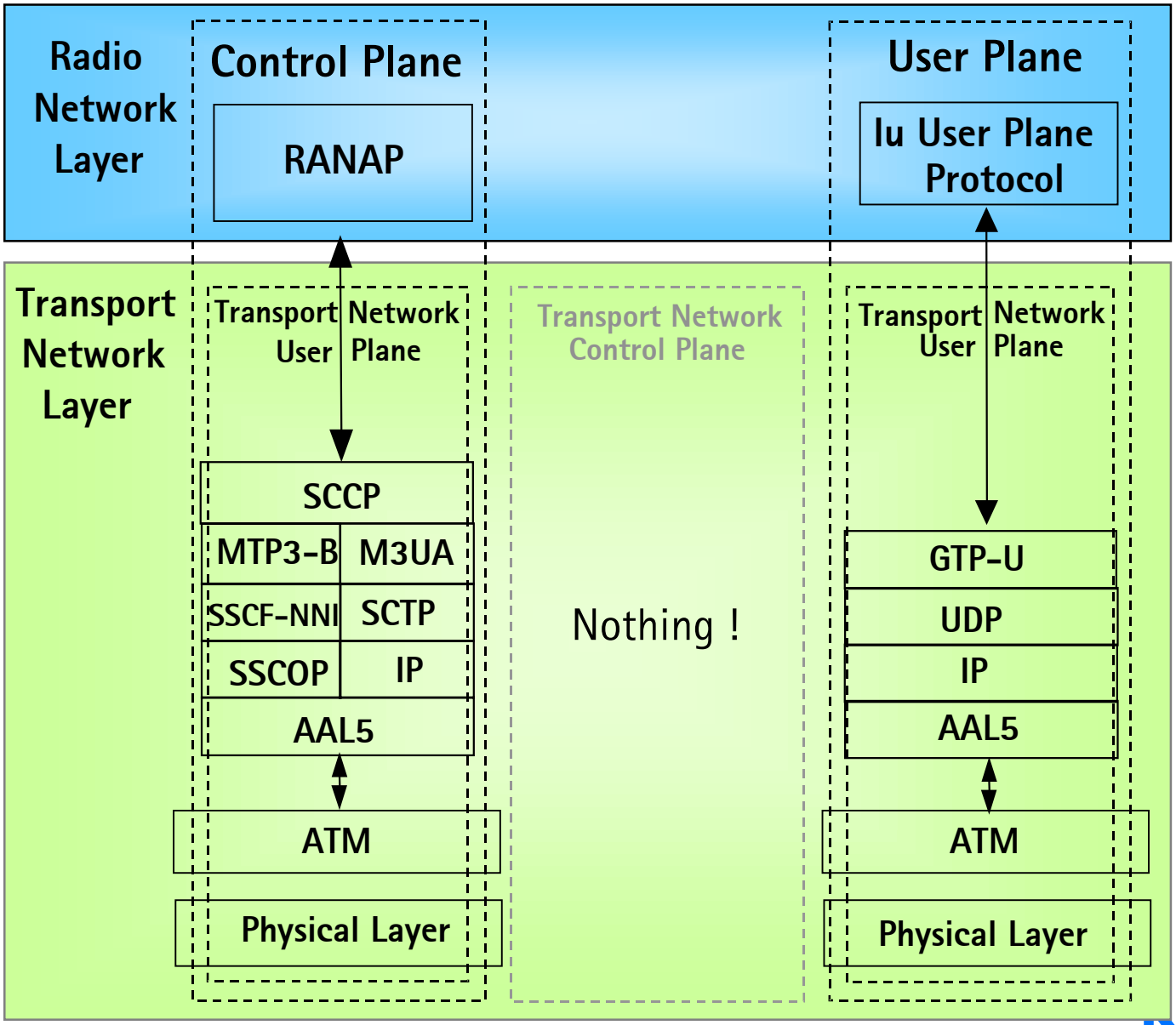
Iu Functional Split Principles

- All Radio Related matters in Radio Network and all Service Related matters in CN
- Most Functions in Iu include both aspects
  - Split responsibility
  - UTRAN provides Services to the CN
- Usual case: CN "controls" and UTRAN "provides"

Iu CS Protocol Structure



Iu PS Protocol Structure



RANAP Functions 1/2

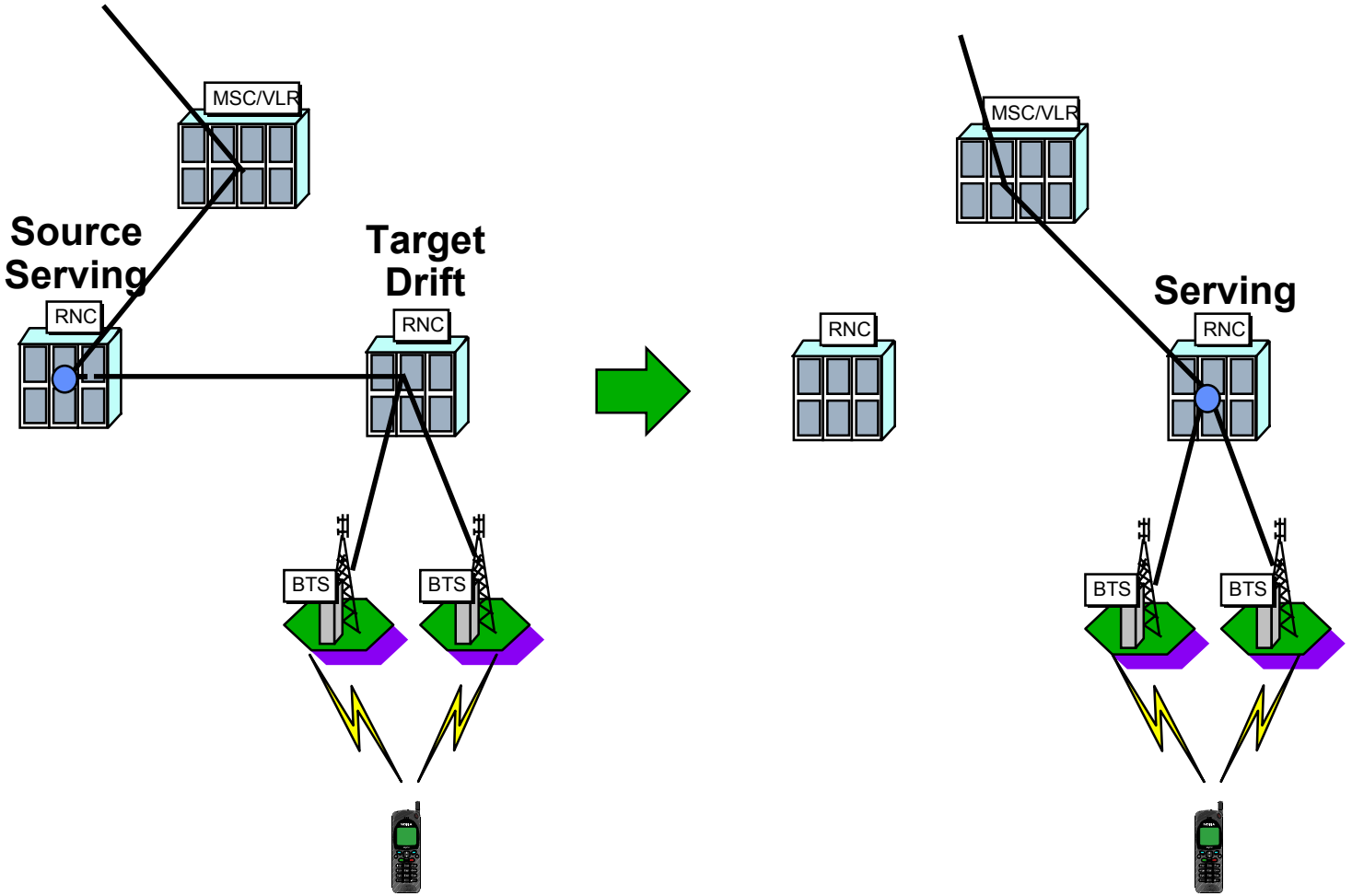
- Radio Access Bearer (UE - CN bearer) handling (combined procedure);
  - RAB Set-up (Including Queuing)
  - RAB Modification
  - Clearing RAB (Including RAN initiated case)
- Iu Release; Releases all Iu resources (Signaling link and U-Plane) related to the specified UE. Also includes RAN initiated case.
- Relocation; Handling both SRNS Relocation (UE already in target RNC with Iur) and Hard Handover (simultaneous switch of Radio and Iu). Includes Loss-less relocation and Inter system Handover
- Paging: CN to page an idle UE for a terminating call/connection
- Common ID: UE NAS Id sent to RNC for paging co-ordination
- Trace Invocation: CN may request UTRAN to start/stop tracing a specific UE
- Security Mode Control; Controls Ciphering and Integrity Checking.

RANAP Functions 2/2

- Location Reporting; Requesting (CN) and reporting (RNC) UE location
- Data Volume Reporting; Requesting (CN) and reporting (RNC) Unsuccessfully transmitted DL data
- Initial UE Message: Carries the first NAS message to the CN and sets up the Iu signalling connection.
- Direct Transfer: Carries NAS signalling information over Iu. Content not UTRAN interpreted by UTRAN
- *CN Information Broadcast; This procedure allows the CN to set CN (NAS) related system information to be broadcast to all users. WILL BE DELETED from R99!*
- Overload; Used for flow control (to reduce flow) over the Iu interface e.g. due to processor overload at CN or UTRAN
- Reset; It is used to reset the CN or the UTRAN side of Iu interface in error situations. Includes also resetting Signalling Connection
- Error Indication; Used for protocol errors where no other error applies

Iu Interface Functional Example

Connections in Serving RNC Relocation



Serving RNC Relocation triggered

Resulting Connection

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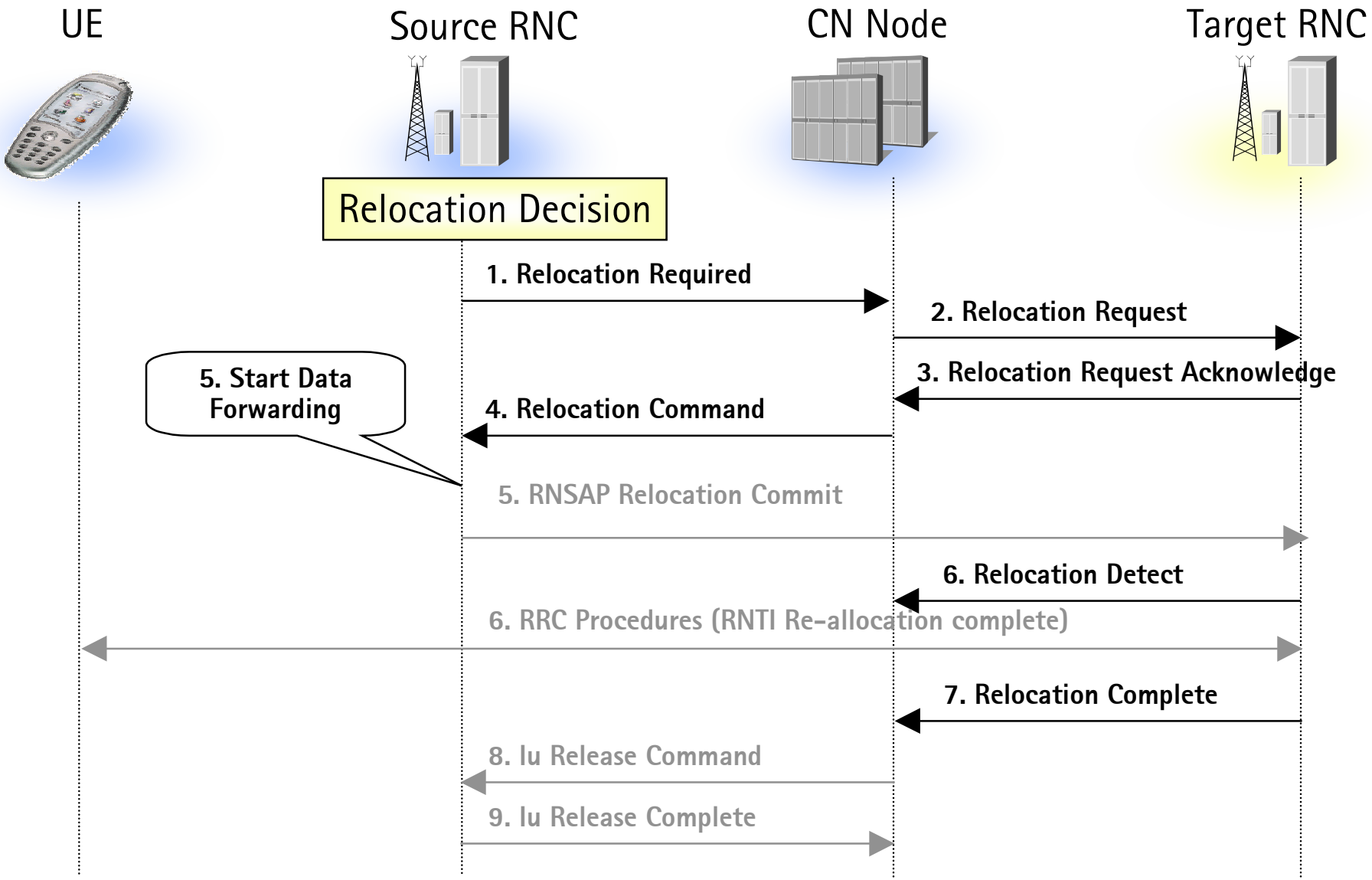
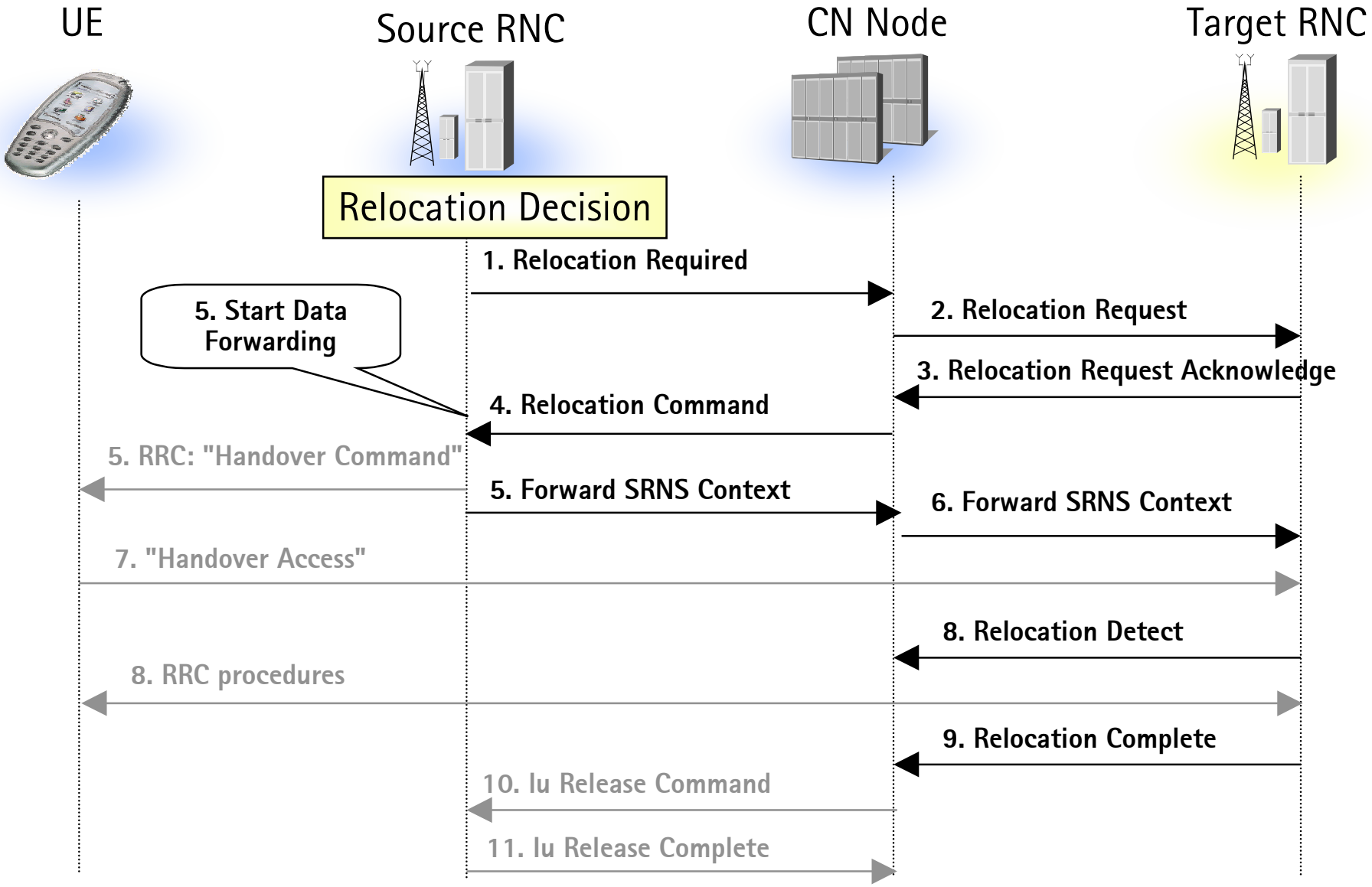
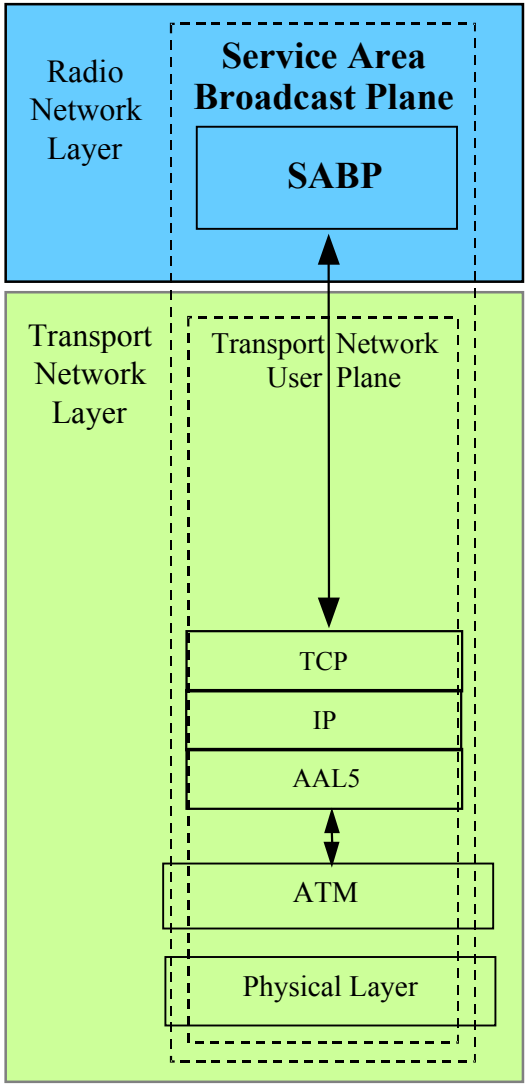
Relocation, UE Not Involved



Relocation, UE Involved



Iu BC Protocol Structure



SABP Functions

- Message Handling. This function is responsible for the broadcast of new messages, replacing existing broadcasted messages and to stop the broadcasting of specific messages. Also message status inquiry is included.
- Load Handling. This function is responsible for determining the loading of the broadcast channels at any particular point in time.
- Reset. This function permits the CBC to end broadcasting in one or more Service Areas. Also Restart indication is included.
- Error and Failure Handling. This function allows the reporting of general and function specific error situations.

Iu Frame Handling Protocol

Modes of Operation

- Transparent Mode
  - For RABs requiring no special handling from Iu
  - Only transport of the user data without framing
  - *Usage Example:* GTP PDUs (PS domain)
- Support Mode for predefined SDU size
  - Provides special services for handling RABs
  - Uses framing of user data
  - 3 PDU Types:
    - control data (PDU Type 14)
    - user data with error detection scheme (PDU Type 0),
    - user data without error detection scheme (PDU Type 1)
  - *Usage Example:* AMR speech PDUs (CS domain)

Support Mode Control Functions

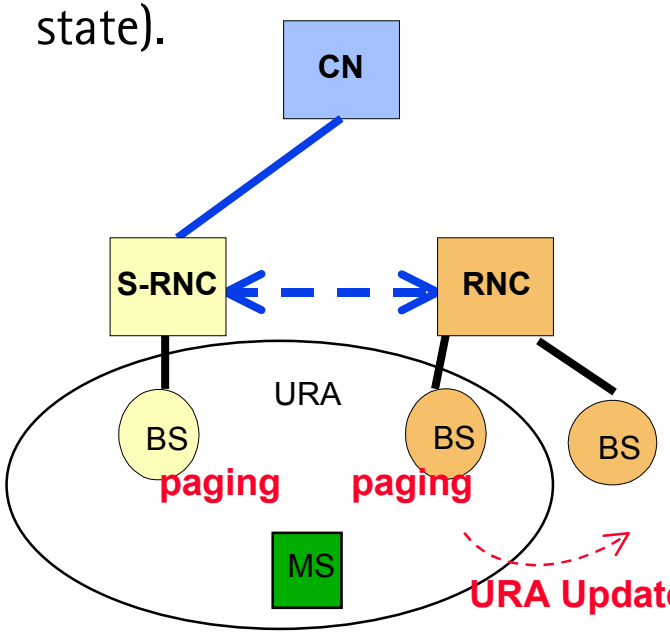
- Initialisation
- Transfer of User Data
  - Transfer of User Data PDU may include *Frame Quality Classification*
- Rate Control
- Time Alignment
- Handling of Error Event

Iur Interface

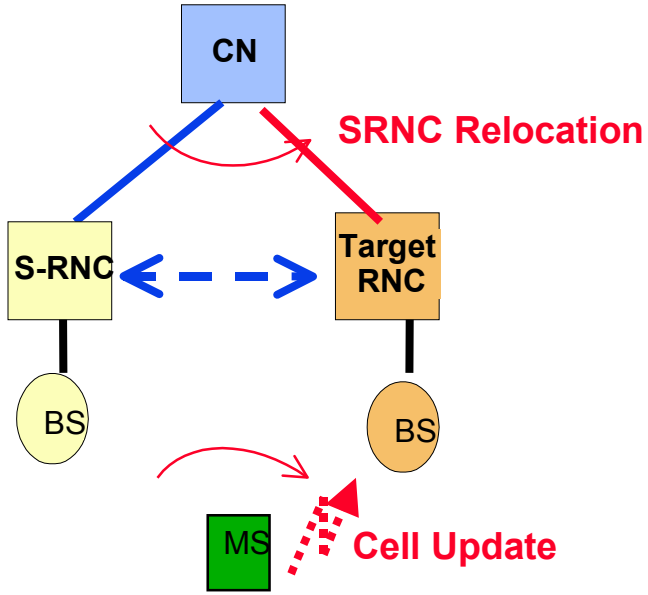
Functional Modules (1/3)

Support basic inter RNC mobility

- Allows inter RNC URA update and paging in multiple RNCs (User in RRC URA_PCH (or CELL_PCH) state).



- Allows the Inter RNC cell update + SRNC relocation (User in RRC CELL_FACH state).

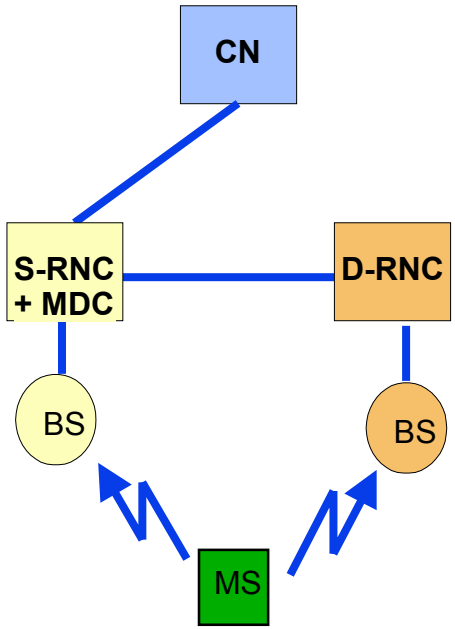


- Only signalling, no user data
- Note: Iur interface does not need to be involved in Inter RNC hard handover

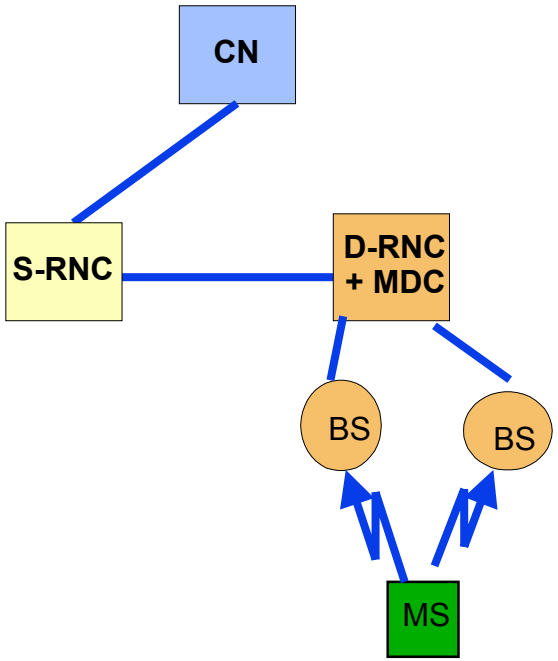
Functional Modules (2/3)

Support dedicated channel traffic between two RNCs

- Allows inter RNC soft handover



- Allows anchoring SRNC when the User is in dedicated channel state

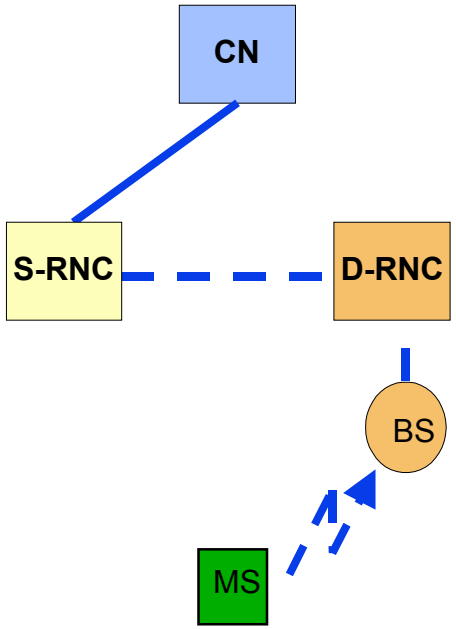


- Support user data transfer with dedicated connection
- Support of downlink shared transport channel (DSCH)

Functional Modules (3/3)

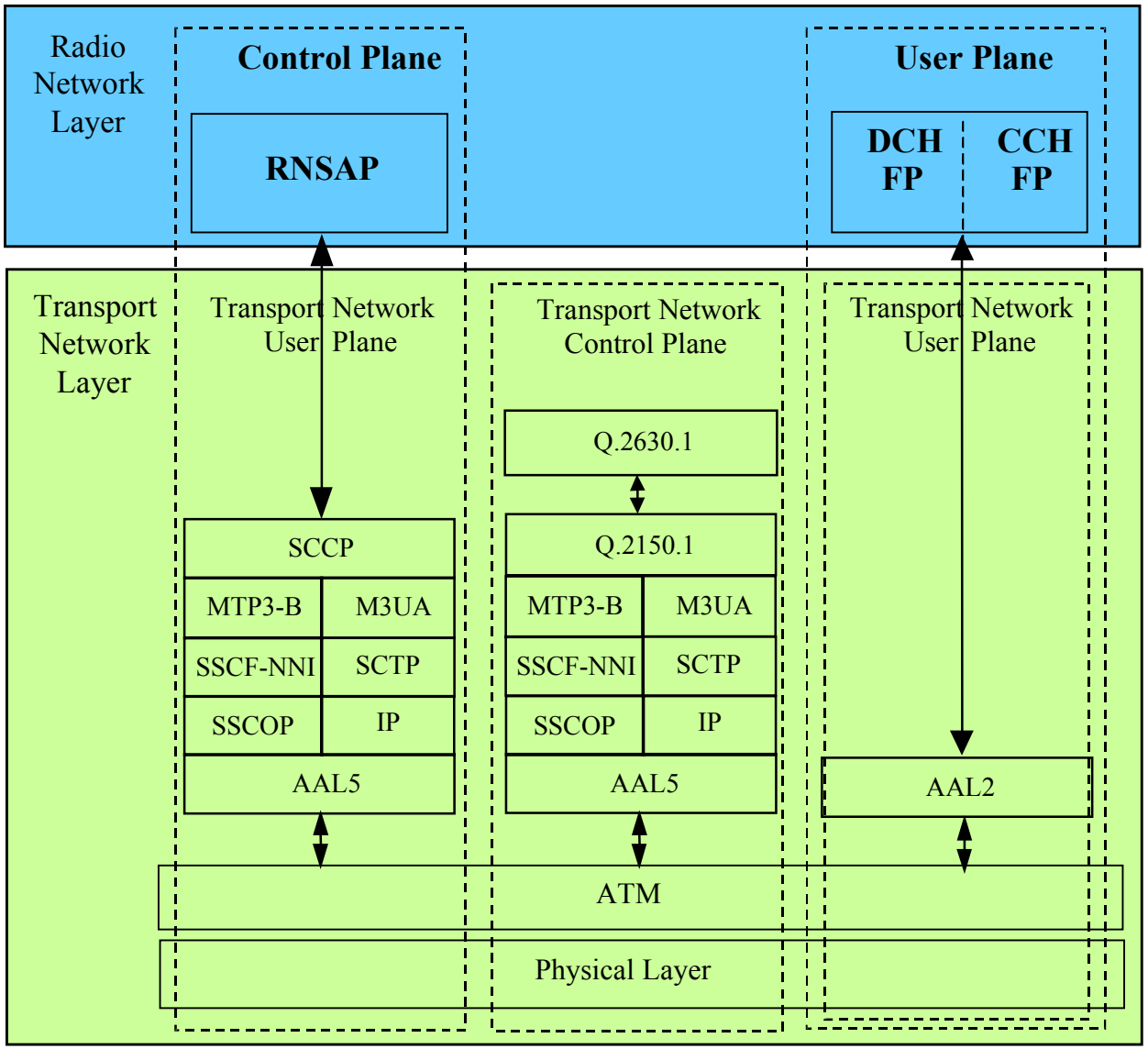
Support common channel traffic between two RNCs

- Allows anchoring of SRNC also when UE is in common channel (RACH/FACH) state
- Support user data transfer with common transport connection
- *Benefits unclear for best effort traffic (reduced signalling load in CN, but increased complexity in UTRAN and less efficient use of radio resource).*



- Also fourth module Global, with Error Indication functionality exists

Iur protocol structure



RNSAP Functions 1/2

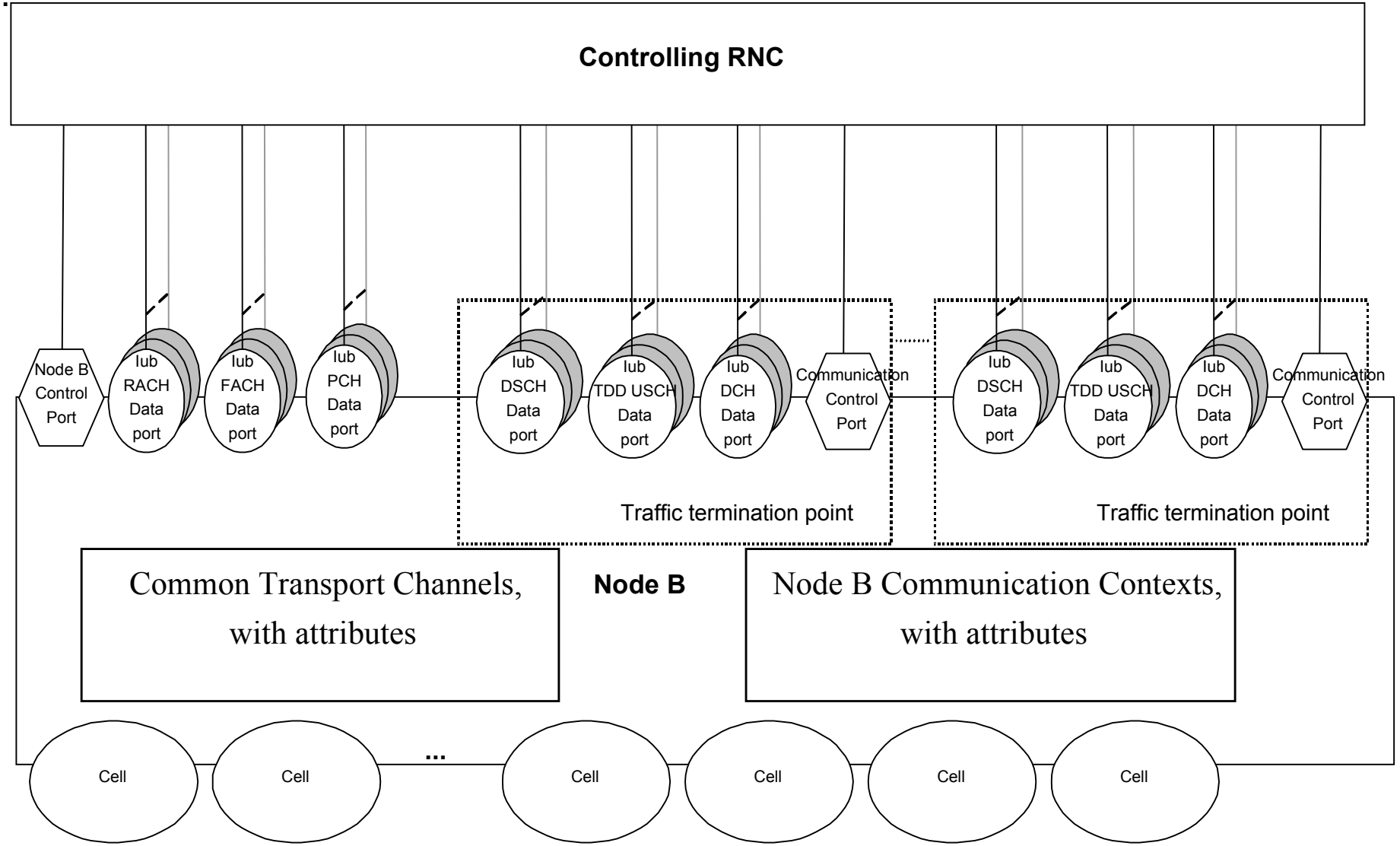
- Radio Link Management. This function allows the SRNC to manage radio links using dedicated resources in a DRNS.
- Physical Channel Reconfiguration. This function allows the DRNC to reallocate the physical channel resources for a Radio Link.
- Radio Link Supervision. This function allows the DRNC to report failures and restorations of a Radio Link.
- Compressed Mode Control [FDD]. This function allows the SRNC to control the usage of compressed mode within a DRNS
- Measurements on Dedicated Resources. This function allows the SRNC to initiate measurements on dedicated resources in the DRNS. The function also allows the DRNC to report the result of the measurements.
- DL Power Drifting Correction [FDD]. This function allows the SRNC to adjust the DL power level of one or more Radio Links in order to avoid DL power drifting between the Radio Links.

RNSAP Functions 2/2

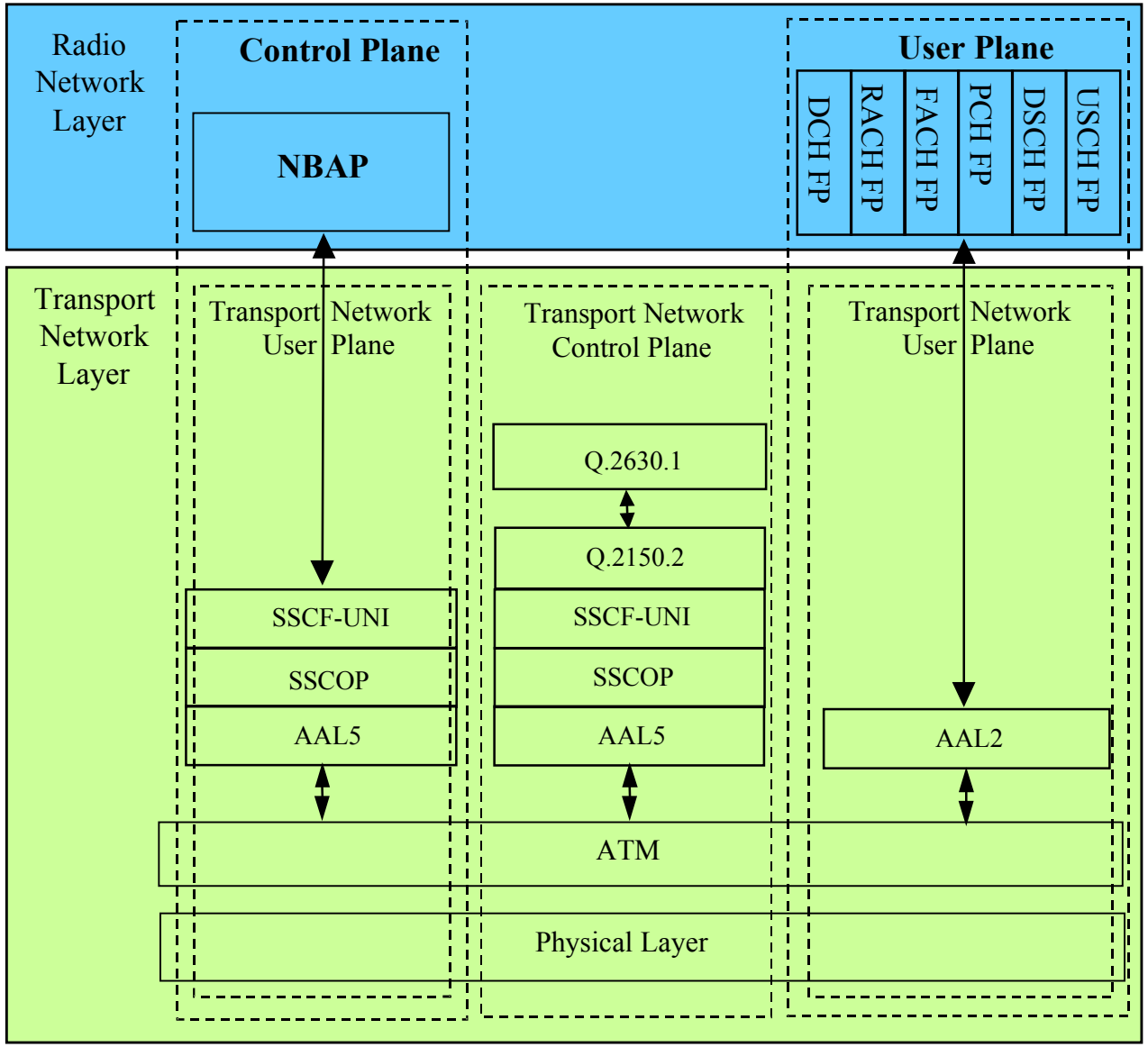
- CCCH Signalling Transfer. This function allows the SRNC and DRNC to pass information between the UE and the SRNC on a CCCH controlled by the DRNS.
- Paging. This function allows the SRNC to page a UE in a URA or a cell in the DRNS.
- Common Transport Channel Resources Management. This function allows the SRNC to utilise Common Transport Channel Resources within the DRNS (excluding DSCH resources for FDD).
- Relocation Execution. This function allows the SRNC to finalise a Relocation previously prepared via other interfaces.
- Reporting general error situations. This function allows reporting of general error situations, for which function specific error messages have not been defined.

Iub Interface

Logical Model of Node B in FDD



Iub Protocol Structure



NBAP Functions 1/2

- Cell Configuration Management. This function gives the CRNC the possibility to manage the cell configuration information in a Node B.
- Common Transport Channel Management. This function gives the CRNC the possibility to manage the configuration of Common Transport Channels in a Node B.
- System Information Management. This function gives the CRNC the ability to manage the scheduling of System Information to be broadcast in a cell.
- Resource Event Management. This function gives the Node B the ability to inform the CRNC about the status of Node B resources.
- Configuration Alignment. This function gives the CRNC and the Node B the possibility to verify that both nodes has the same information on the configuration of the radio resources.
- Measurements on Common Resources. This function allows the CRNC to initiate measurements in the Node B. The function also allows the Node B to report the result of the measurements.

NBAP Functions 2/2

- Synchronisation Management.(TDD) This function allows the CRNC to manage the synchronisation of a TDD cell in a Node B.
- Radio Link Management. This function allows the CRNC to manage radio links using dedicated resources in a NodeB.
- Radio Link Supervision. This function allows the CRNC to report failures and restorations of a Radio Link.
- Measurements on Dedicated Resources. This function allows the CRNC to initiate measurements in the NodeB. The function also allows the NodeB to report the result of the measurements.
- DL Power Drifting Correction (FDD). This function allows the CRNC to adjust the DL power level of one or more Radio Links in order to avoid DL power drifting between the Radio Links.
- Reporting general error situations. This function allows reporting of general error situations, for which function specific error messages have not been defined.

Iur and Iub Frame Handling Protocols

Iur & Iub Frame Protocols

- Dedicated Channel Frame Protocol
  - One common protocol for Iur and Iub Interfaces
- Common Cannel Frame Protocols
  - Separate protocols for Iur and Iub Interfaces
- All of them include
  - Control Functions (Mostly similar as in Iu Frame Protocol)
  - Data Frame Transfer